SOME FEATURES OF ORNAMENTATION IN THE KILLIFISHES OR TOOTHED MINNOWS

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THE killifishes, so named by the early Dutch settlers about New York from their habit of living in the channels or kills, embrace an interesting family of fishes. They are known by other names, as top-minnows, cyprinodonts, toothed minnows, millions fish, etc. Some of these names are, however, more limited in scope and pertain to sections or genera. Top-minnow was applied from the habit of many living at the surface, and cyprinodont, meaning toothed carp, arose as some greatly resemble very small carps or true minnows (Cyprinidæ), though were found to differ in the presence of teeth in their jaws. Besides this character are a number of others, in which they agree with several related families to form the order of pike-like fishes (Haplomi). Such are all internal and largely have reference to the bony skeleton. In the abdominal ventral fins (*Procatopus* excepted), and without true spines in the dorsal and anal fins, the order resembles the herring-like fishes (Isospondyli), but differs in the absence of a mesacoracoid bone. This latter character is in agreement with the host of spiny-rayed fishes (Acanthopteri), but they usually have the ventral fins well anterior.

Though six families are included in the order of pike-like fishes, only the mud-minnows (Umbridæ) and the pikes (Esocidæ) occur in the Middle Atlantic States. The killifishes differ from both in the extremely protractile premaxillary bones, a condition very easily demonstrated by examining the upper jaw and prodding its edge forward. In form the body is oblong from elongate and slender to deep and nearly orbicular. The head is usually large and robust, often quite chunky. The mouth is small, with short gape, though wide and terminal. The teeth are extremely diverse, from broadly incisor-like to finely

villiform, and usually occur only in the jaws. The pharyngeal bones, unlike those of the true minnows or cyprinoids, often have fine teeth, rarely molar, and never modified or in even numbers as in cyprinoids. The scales are mostly large, cycloid, adherent, regular and without a perfected lateral line. The dorsal and anal fins are single, inserted usually behind the middle of the body, but no adipose fin developed. The caudal is broad and, though sometimes pointed, not forked. The paired fins are placed low, and the ventrals abdominal.

Many genera and species, about sixty belonging to the first and over three hundred to the last, have been described. Of these about ten genera and fifty species occur in the United States. The family reaches its greatest diversity in tropical America, and in the Old World the largest number of forms occur in African fresh waters. Killifishes live in fresh waters in nearly all situations, in lakes of great elevation, or in sandy desert streams, puddles and ponds. Others live in tidal waters, or along the shores of sea-beaches, and all near or close to the surface. The great changes with age, sex and season render many of the species difficult of determination. All are of small size, less than a foot in length.

In nearly all killifishes the sexual differences are well marked, at least during the spawning or breeding season. Often the males have enlarged fins, smaller in the females, as in the may-fish (*Fundulus majalis*) and the zebra-fish (*Fundulus zebrinus*). Still other characters occur in some species which have been entirely overlooked or scarcely noticed by most writers. These are the minute spines, or spinules, adorning the scales and fin-rays of certain species during the spawning-season. Garman, in his celebrated monograph of the killifishes,[1] simply says, "a minor sexual character is that of small spines appearing on the fins of males in several genera in the breeding time." I have been unable to find any detailed account of these structures, except casual reference to a few in descriptions of species. These are usually quite short and

[1] *Mem. Mus. Comp. Zool.*, XIX, 1895, p. 11.

of but slight value. So far as I have been able to examine material, these little spines occur only in certain species of the true killifishes, the pursy-minnows and the four-eyed fishes, or the Fundulinæ, Cyprinodontinæ and the Anablepinæ, respectively. I have never seen any in the top-minnows. It is interesting to note that the four-eyed fishes, creatures with remarkable and extreme modifications of structure, should be the only group of viviparous forms in which the spinules have so far been found to occur. These spinules are different in several ways from the nuptial tubercles of cyprinoids, in that they are more permanent, though very minute and inconspicuous. They may easily be overlooked in preserved examples, owing to the mucus exuded and covering the scales and fins. This should be carefully cleaned away, before they can be detected, and even then only with a good lens. Each spinule is found to arise on or close to the edge of the scale, and not on its exposed surface, as the more distinctly straight conic tubercles of the cyprinoids. The spinules are not always perfectly firm and rigid, but may be flexible or delicate. Those on the anal fin rays are generally curved slightly and are also often close together, though not perfectly regular. Their arrangement or design is usually more or less complete in each species. At least in one species their development occurs in the young, as in the ornatus stage of the common mummichog. Probably the spinules in most species are not permanent, but disappear after the spawning-season. However, if the spawning-season for a certain species is protracted, males with spinules may be found for a period of several months. Preserved specimens of killifishes do not show scars or pits like cyprinoids, and it may be that the spinules wear away as well as drop off. I have not found any examples with spinules in cold weather, or when spawning was apparently over. In no case have the inner edges of the pectoral rays been found with spinules, like the tubercles of certain cyprinoids. Doubtless such developments are to be correlated with the spawning habits, as none of the

EXPLANATION OF FIGURES

All the figures are drawn to the scale of millimeters and the accompanying numbers signify such, so that the number of times the line is contained in the lengthwise diameter of the figure will give its dimensions.

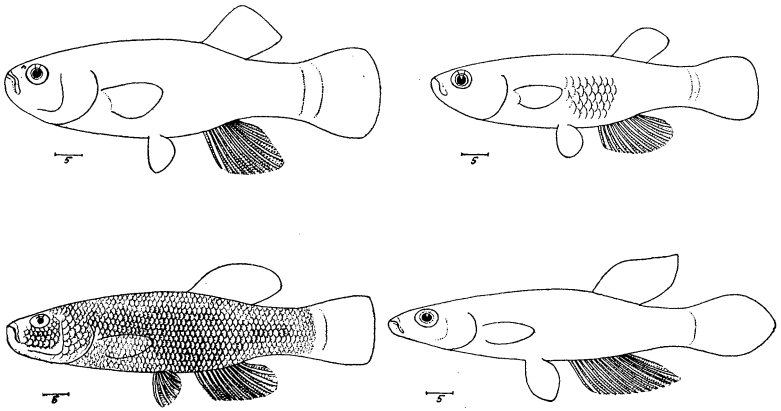

PLATE 1

Fundulus nisorius Cope.
Fundulus zebrinus Jordan and Gilbert.
Fundulus floripinnis (Cope).
Fundulus stellifer (Jordan).

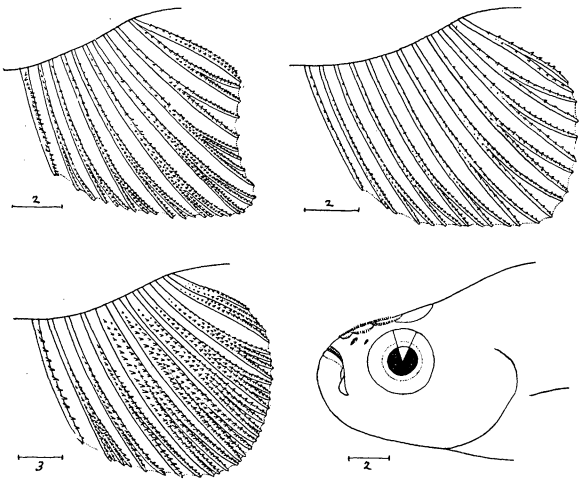

PLATE 2

Fundulus heteroclitus macrolepidotus (Walbaum).
Cyprinodon bovinus Baird and Girard.
Fundulus diaphanus (Le Sueur).
Lucania parva (Baird).

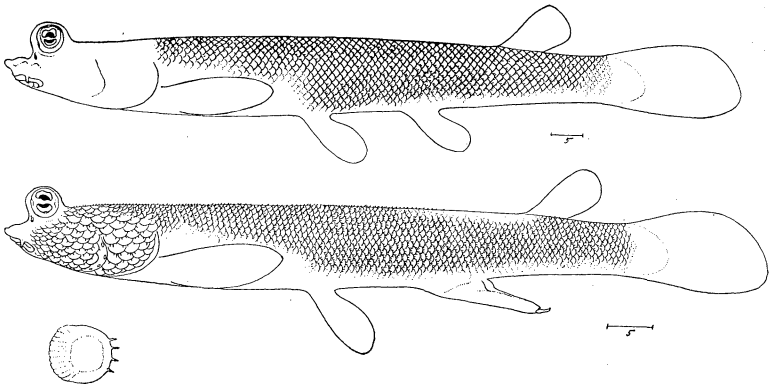

PLATE 3

Anableps anableps (Linné). Upper figure female, lower male, and enlarged scale to left.

killifishes have been seen to clasp the female as Reighard describes the creek chub (*Semotilus atromaculatus*). In the spawning behavior of the mummichog I could not determine if the male in any way secured or held fast to the female by means of his anal spinules, though possibly they may be of some such use. Killifishes greatly parasitized with sporozoa or myxosporidia have been found, the adult spawning-males sometimes greatly distorted, though with the development of the spinules more or less perfected. Among species of killifishes represented by spawning-males without spinescent ornamentation which I have examined are *Fundulus punctatus, F. similis, F. majalis, F. luciæ, F. nottii* and *F. notatus.*

In the common killifish or mummichog (*Fundulus heteroclitus macrolepidotus*) of the tidal waters of our Atlantic coast, the male is furnished with little spinules on the anal rays. They are better developed on the outer or terminal branches of the rays. They are also often irregularly placed, though usually a pair may be found on each segment, or as a spinule projecting out on each side of the fin. None of the scales or other fins with spinules. Spawning-males 76 to 82 mm. long. The female has a well-developed anal tube extending along the front of the anal fin for at least half the length of the depressed fin.

My examples 92 to 96 mm. Spawning fishes of this species were obtained from April until the middle of August.

In the West African killifish (*Fundulus nisorius*) the male has the outer portions of the anal rays covered with little spinules. It is also quite likely that the anal fin is furnished with spinules in the spawning *Fundulus bermudæ*.

The barred killifish (*Fundulus diaphanus*) common in the fresh waters of the east, from Maine to Carolina, is quite brilliant in the spawning-season. In the male the spinules are arranged as little points, like those of the mummichog, though as the fish is smaller they are less conspicuous. The scales and fins other than the anal are without spinules. Spawning males 60 to 70 mm. In the female a well-developed basal anal sheath extends around the front of the anal fin. Spawners of this species in full color were obtained from April until the middle of August.

The zebra-fish (*Fundulus zebrinus*) of the Mississippi Valley region has long been noted for its prickly appearance. Jordan and Evermann state, presumably with reference to spawning fish, "in males the margins of both dorsal and anal fins are evenly rounded, the anal the higher, its rays beset with minute white prickles." My examples show it differs from any of the preceding species in the male having the sides with the scales minutely spinescent along their edges. The area of spinescent scales extends from the head in some examples, in others for variable distances, back to caudal base, and always with its greatest development over the base of the anal fin. On the back the spinules gradually disappear, and the same is true on the under surface of the caudal peduncle. Further, an additional modification is seen in the presence of spinules on the inner or hind surfaces of the ventrals, though these fewer than on the anal rays. On the front of the anal fin the spinules are best developed, though irregularly distributed on the segments of the fin-rays, here and there appearing crowded or sparse.

Length 48 to 75 mm. The female has a broad basal sheath around the front of the anal fin. Length 51 to 63 mm.

The little green killifish (*Fundulus floripinnis*) of the South Platte River basin has the male with the scales along the middle of the side, especially above the base of the anal, with minute prickles along their edges. Similar prickles also occur on the rays of the anal fin, though with irregular distribution on the segments. They usually appear better developed along the front anal edge. I have also seen a few minute prickles above the eyes. In length these males were 47 to 57 mm. This species belongs to the section *Zygonectes* Agassiz, so called as the fishes were said to swim in pairs. Doubtless this would refer to the spawning-habits or when spawning, for at other times they do not appear to swim in pairs. As in the brown killifish (*Fundulus luciæ*), another member of the *Zygonectes* group, I have never seen them swimming in pairs, and Ellis claims the same for the little green killifish.

In the stud-fish (*Fundulus stellifer*) the males have very minute spinules along the anal rays and along the edges of their scales above the fin. They are also irregularly placed. Length 82 to 99 mm., and the females 73 mm. long have a well-developed basal anal sheath at the front of the fin. The related *Fundulus catenatus* shows similar ornamentation in the male, though my material is inadequate for detailed comparison.

In the rainwater-fish (*Lucania parva*) males in high color, taken in June, differ from any other killifish I have examined in the presence of minute spinules on the upper surface of the snout, in some cases even encroaching on the interorbital space. No other spinules occur. The muzzle of the male is also modified or decidedly obtuse, suggestive of the fat-head minnows (Pimephales).

The pursy-minnows (*Cyprinodon variegatus*) when in brilliant spawning-dress, in the case of the males, are extensively provided with minute spinules. These extend all along the edges of the scales on the head, front predor-

sal region, posterior sides of trunk or above anal fin, and front side of caudal peduncle. All the anal rays are also minutely and finely spinescent, though I have not found any spinules on the paired fins. Spawning-males 54 to 57 mm., and the females smaller. The related *Cyprinodon bovinus* of the southwest is similar. *Jordanella floridæ* is represented only by one small example with spinules, these very minute along the edges of the scales above the anal. No spinules found on any of its fins.

In the four-eyed fish (*Anableps anableps*) of South America, the males have an intromittent organ dextral or sinistral. They also have the scales on the trunk, especially above the anal and on the predorsal region, with spinules, though more numerous or dense with spinules in the former space. Top of head, belly and lower surface smooth. Sides of caudal peduncle with a few scattered spinules. A large female, 244 mm. long, is largely spinescent on the trunk above, though the spinules not so dense as on scales above the anal in the male. In females of smaller size, 124 to 128 mm. long, the spinules are rather obsolete, sparse and scattered, also only on the back and sides above. Young 27 mm. long still show the umbilical sac well developed and are scaleless.

Though I have not examined spawning examples of small-finned killifish (*Fundulus parvipinnis*), Jordan and Gilbert state, "scales large; in the males in spring roughened or ctenoid by small granulations and prickles, similar to the nuptial excrescences of some Cyprinidæ; fins also rough."